Statement to the United States Commission on Ocean Policy

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HYPOXIA IN THE GULF OF MEXICO: CAUSES, EFFECTS, AND ENVIRONMENTAL EFFECTS

Admiral Watkins, distinguished members of the Commission, and guests, I am Dr. Nancy N. Rabalais of the Louisiana Universities Marine Consortium, and I have been asked to present to you information concerning hypoxia (= low oxygen) in the Gulf of Mexico. This written statement supplements published materials that were submitted to you earlier:

- Rabalais, N. N. and R. E. Turner. 2001. Hypoxia in the Northern Gulf of Mexico: Description, causes and change. Pages 1-36 in N. N. Rabalais and R. E. Turner (eds.), Coastal Hypoxia: Consequences for Living Resources and Ecosystems. Coastal and Estuarine Studies 58, American Geophysical Union, Washington, D.C.
- Rabalais, N. N., R. E. Turner and D. Scavia. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52: 129-142.

While my presentation today focuses on the situation in the Gulf of Mexico, similar areas of low oxygen and degraded water quality resulting from an excess of nutrients delivered to estuaries and coastal areas are a matter of concern throughout the United States and the world. There are clear signals that humans have altered the global cycles of nitrogen and phosphorus [and silicon (in some cases)] over large regions and increased the mobility and availability of these nutrients to marine ecosystems. Other symptoms of excess nutrients that lead to increased production of algae are ultimately expressed as noxious and toxic algal blooms, increased turbidity with a subsequent loss of submerged aquatic vegetation, disruption of ecosystem functioning, loss of habitat, loss of biodiversity, shifts in food webs, and loss of harvestable fisheries. The factors that lead to these degraded coastal waters begin elsewhere in the watersheds and airsheds that deliver nutrients (nitrate, phosphate, and silicate) to the coastal ocean, from both point and but mostly diffuse, nonpoint sources.

Hypoxia in the Gulf of Mexico is a symptom of worsening water quality seen elsewhere that was the impetus for one of the eight points presented to The Commission by the Ocean Studies Board in a letter from Dr. Ken Brink last fall. I currently chair the OSB and wish to re-emphasize this issue, namely “impacts of land-based activities on coastal areas.” The point is that the oceans, coastal seas and estuaries are intimately linked to the land and air that border them and deliver water, sediments, nutrients, and pollutants to coastal waters.

Myself, Gene Turner, and Bill Wiseman of Louisiana State University have been studying the distribution and dynamics of Gulf hypoxia since 1985, along with other LSU and LUMCON collaborators (Dubravko Justić, Barun Sen Gupta, and Quay Dortch) to define its characteristics, changes through time, and changes in relation to landscape use in the Mississippi River watershed and its freshwater and nutrient delivery. This research was instrumental in the formulation of the federal interagency Integrated Assessment of Gulf of Mexico Hypoxia, the Hypoxia Action Plan submitted to Congress by the Clinton administration, and the beginnings of implementation of the Hypoxia Action Plan under the Bush administration. The Action Plan was approved by 7 federal agencies, 9 states, and 2 tribal nations at an October 2001 meeting in Baton Rouge, Louisiana. The recently reconvened Mississippi River/Gulf of Mexico Watershed Nutrient Task Force met in St. Louis, Missouri in February 2002 to initiate the Hypoxia Action Plan.

The second largest zone of coastal hypoxia (= oxygen depleted waters, also called the "Dead Zone") in the world is on the continental shelf adjacent to the outflows of the Mississippi and Atchafalaya rivers. The physical structure of the water column and the algal production are influenced by the fresh water and nutrients from these rivers, which are responsible for the annual formation of the hypoxic water mass. Paleoindicators in dated sediment cores indicate that hypoxic conditions likely began around the turn of the last century and became more severe since the 1950s as the nitrate load from the Mississippi River increased by 300% while fertilizer use in the watershed also increased. While increasing nutrient loads enhance the production of some organisms, others are forced to migrate from the area or they die when the oxygen level falls below 2 mg/L, ppm. Given the high tonnage (Gulf menhaden) and dollar value (shrimp fishery) of commercial fisheries on the Louisiana coast, any large-scale environmental perturbation like the low oxygen deserves focused and long-term attention.

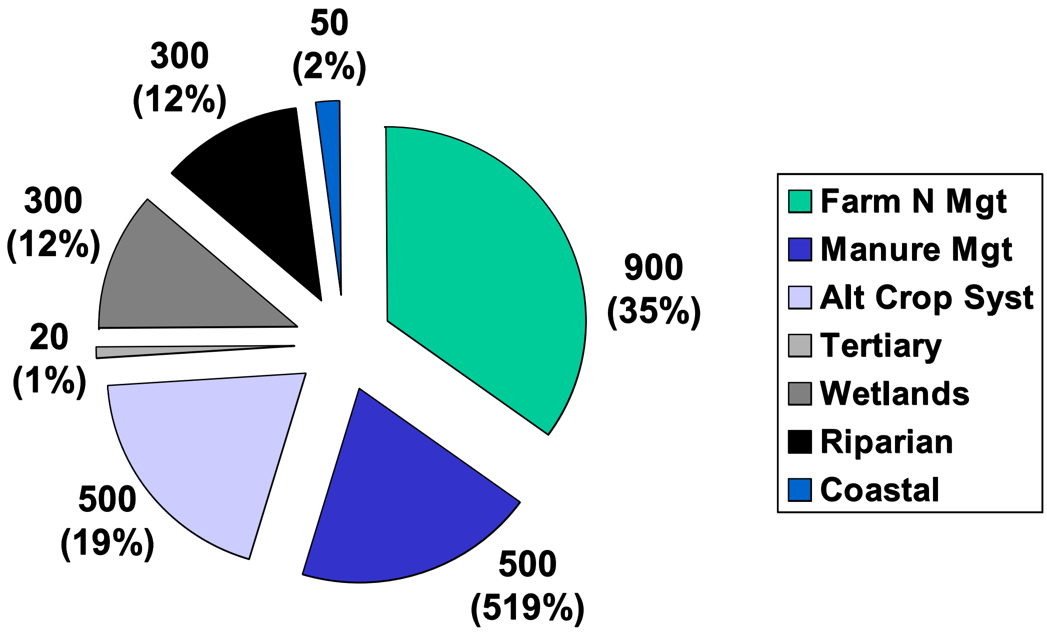
When the oxygen depletion, the ability of organisms to reside either at the bottom or within the water column or even their survivability, is affected. When oxygen levels fall below critical values, those organisms capable of swimming (e.g., demersal fish, portunid crabs and shrimp) evacuate the area. The stress on less motile fauna varies, but they also experience stress or die as oxygen concentrations fall to zero. Important fishery resources are variably affected by direct mortality, forced migration, reduction in suitable habitat, increased susceptibility to predation, changes in food resources and disruption of life cycles. Prolonged oxygen depletion can cause mass mortalities in aquatic life, disrupt aquatic communities, cause declines in biological diversity, impact the capacity of aquatic systems to support biological populations, and disrupt the natural cycling of elements.

The effects of eutrophication, including hypoxia, are well known for some systems and include the loss of commercially important fisheries. Comparisons of ecosystems along a gradient of increasing nutrient enrichment and eutrophication or changes of a specific ecosystem over time through a gradient towards increasing eutrophication, provide information on how nutrient enrichment affects coastal communities. There is a continuum of fishery yield in response to increasing eutrophication. In waters with low nutrients, the fishery yield is low. As the quantity of nutrients increases, the fishery yield increases. As the ecosystem becomes increasingly eutrophied, there is a drop in fishery yield but the decreases are variable. The benthos are the first resources to be reduced by increasing frequency of seasonal hypoxia and eventually anoxia; bottom-feeding fishes then decline. The loss of a planktivorous fishery follows as eutrophication increases, with eventually a change in the zooplankton community composition. Where the current Gulf of Mexico fisheries lie along the continuum of increasing eutrophication is not known.

Knowledge of the sources and amounts of nutrient loads that vary among the many geographic regions affected by increased nutrients helps to guide any measures being taken to reduce those nutrients. For example, increased nitrogen in Long Island Sound is attributed primarily to municipal wastewater whereas for the Mississippi River is primarily agricultural in source. The Mississippi River is the largest source of freshwater and nutrients to the northern Gulf of Mexico. This watershed, like others, has undergone major changes affecting water quality since European immigrants expanded westward in the early 1800s. Major alterations in the morphology of the main river channel and widespread landuse patterns in the watershed, along with anthropogenic additions of nitrogen and phosphorus, have resulted in dramatic water quality changes this century. The river has been shortened by 229 km in an effort to improve navigation, and has a flood-control system of earthwork levees, revetments, weirs, and dredged channels for much of its length. More than half of the original wetlands in the United States have been lost to drainage practices. Water quality in streams, rivers, lakes and coastal waters may change when watersheds are modified by alterations in vegetation, sediment balance, conversion of forests and grasslands to farms and cities, and increased anthropogenic activities that accompany increased population density, e.g., fertilizer application, sewage disposal or atmospheric deposition. The estimate of current river nitrogen export from the Mississippi River is 2.5- to 7.4-fold higher than from the watershed during pre-agricultural and pre-industrial or "pristine" conditions.

In an average year the Mississippi River discharges nearly 1.6 million mt of nitrogen to the Gulf of Mexico, of which 0.95 million mt is nitrate and 0.58 million mt is organic nitrogen. The principle sources of inputs of nitrogen to the Mississippi River system are soil mineralization, fertilizer application, legume crops, animal manure, atmospheric deposition, and municipal and industrial point discharges. The highest inputs within the watershed are above the confluence of the Mississippi and Ohio Rivers, and not surprisingly the yields are from sub-basins where inputs are the greatest. High inputs and yields are characteristic of sub-basins were precipitation is high and agricultural drainage is extensive, resulting in the high rates of transport of soluble nitrate into streams, the Mississippi River and the Gulf of Mexico.

Solving the hypoxia problem in the Gulf of Mexico and improving water quality and habitat within the Mississippi River basin will require a 30% nitrogen load reduction. The Hypoxia Action Plan outlines voluntary, incentive-based sub-basin strategies for reaching that goal. These activities, designed within a series of sub-basin strategies, would include best management practices on agricultural lands, wetland restoration and creation, river hydrology remediation and riparian buffer strips, and storm water and waste water nutrient removal. These sub-basin efforts, which are intended to sum to an overall nitrogen load reduction of 30%, will take place within a larger framework of increasing demand for agricultural products and energy and within a variable climate. The relative proportion of nitrogen removal expected from various activities is illustrated below. It is clear that no single strategy will account for most of the nitrogen removal, but activities that modify agriculture practices and restore wetlands and riparian buffer strips within the Mississippi River basin will provide the most nitrogen removal.



Data Source: Mitsch et al. 2001, CENR 2000.

Reducing excess nutrient delivery to estuarine and marine waters for the improvement of coastal water quality, including the alleviation of hypoxia, requires individual, societal and political will. Proposed solutions are often controversial and have societal and economic costs in a narrow and short-term sense. Yet, multiple, cost-effective methods of reducing nutrient use and delivery can be integrated into a management plan that results in improved habitat and water quality, both within the watershed and the receiving waters. Successful plans with successful implementation and often with successful results span geopolitical boundaries, for example the Chesapeake Bay Agreement, the Comprehensive Conservation and Management Plans developed under the U.S. National Estuary Program for many of the nation's estuaries, a Long Island Sound agreement, the efforts of Denmark, Holland and Sweden, and international cooperation among the nations fringing the Baltic Sea as part of the Helsinki Commission, and hopefully under the Hypoxia Action Plan for the Mississippi River/Gulf of Mexico ecosystem. These efforts are usually more successful in reducing point sources of nitrogen and phosphorus than with the multiple nonpoint sources of high solubility and growing atmospheric inputs of nitrogen. But success it is for several examples in the U.S. and around the world. The growing decline of coastal water quality, and also the proven successes of reducing nutrients, are reasons enough for continued and expanded efforts to reduce nutrient overenrichment and the detrimental effects of hypoxia.

Useful References

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Useful Web Sites

NOAA State of the Coast on Oxygen Depletion (good general description, lots of graphics)
http://state-of-coast.noaa.gov/bulletins/html/hyp_09/hyp.html

USGS site for nutrients and nutrient flux to the Gulf of Mexico (sources, amounts of nutrients)
http://wwwrcolka.cr.usgs.gov/midconherb/hypoxia.html

CENR Hypoxia Assessment Reports, Comments, and Integrated Assessment (6 technical reports on hypoxia, distribution, causes, effects, mediation, economics), Integrated Assessment (a shorter version), public comments on both the technical reports and the Integrated Assessment, and Action Plan.
http://www.nos.noaa.gov/Products/pubs_hypox.html

Downing et al. 1999. Gulf of Mexico Hypoxia: Land and Sea Interactions. Council for Agricultural Science and Technology, Task Force Report No. 134, 40 pp. (a very good verbal and readable accounting of the issue, with excellent graphics)
http://www.cast-science.org/pdf/hypo.pdf

Gulf of Mexico Ecosystem Studies and Hypoxia Assessment, programs of the NOAA Coastal Ocean Program http://www.cop.noaa.gov/projects/GMX.htm

Other information on the Mississippi River/Gulf of Mexico Task force activities is available at:
http://www.epa.gov/msbasin

Mississippi Riverwise Partnership. Their website has many links to other hypoxia web sites including many here, but other as well.
http://www.riverwise.org/

Science Museum of Minnesota web site on the “Dead Zone”
http://www.smm.org/DeadZone/top.html

Effects of Nutrient Enrichment in the Nation's Estuaries
http://cammp.nos.noaa.gov/spo/proddetails.taf?offeringcode=1_SEA_99-13